Trans-Mediterranean Cooperation for Energy Security

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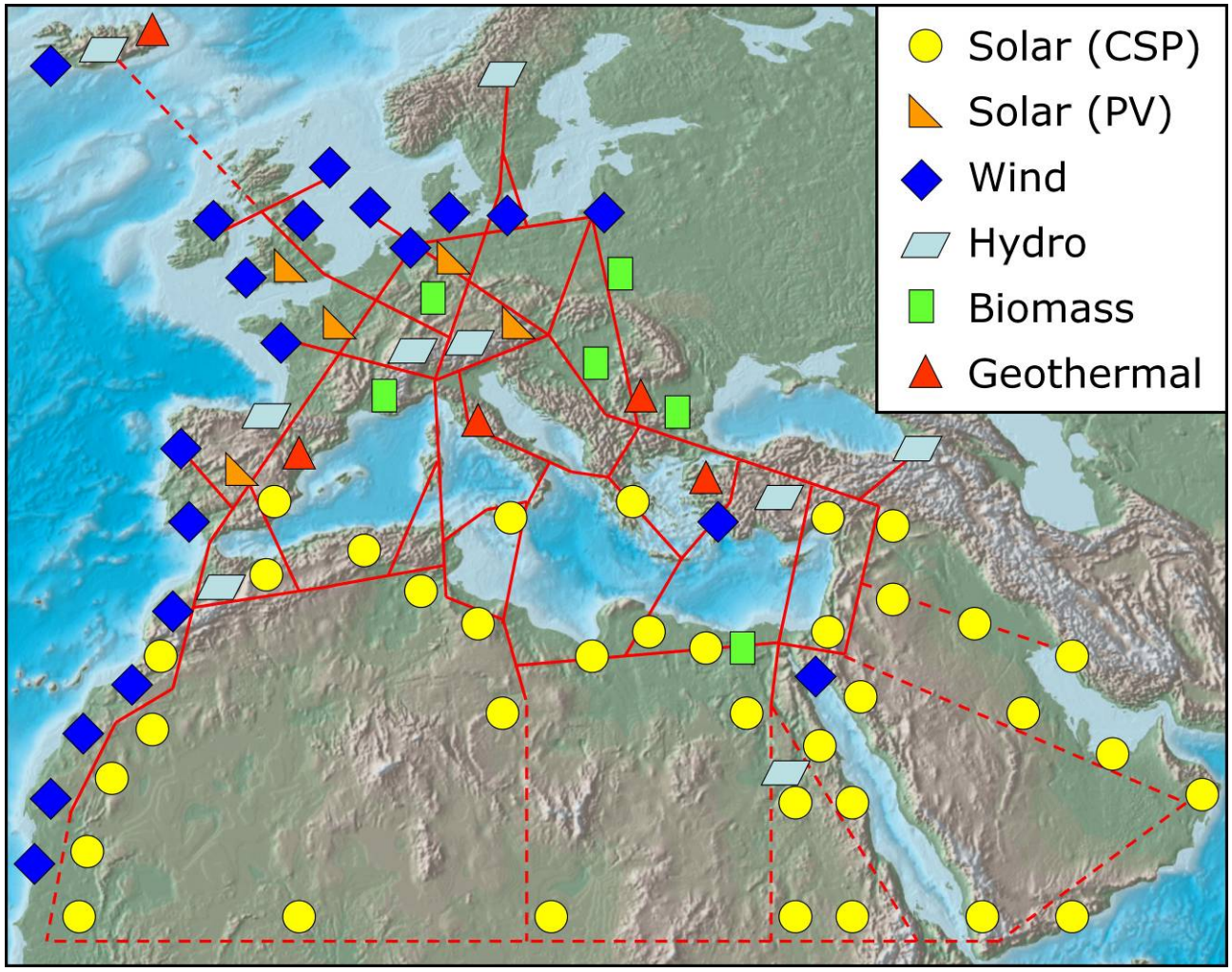
NATO Symposium, Oberammergau, January 20, 2010

Trans-Mediterranean High Voltage Direct Current Electricity Grid: Interstate Highways for Renewable Electricity in EUMENA

TREC
Clean Power from the Deserts
Trans-Mediterranean
Renewable Energy Cooperation
In conjunction with The Club of Rome

THE CLUB OF ROME



EUMENA:
Europe
Middle East
North Africa

Portfolio of Energy Sources for Electricity:

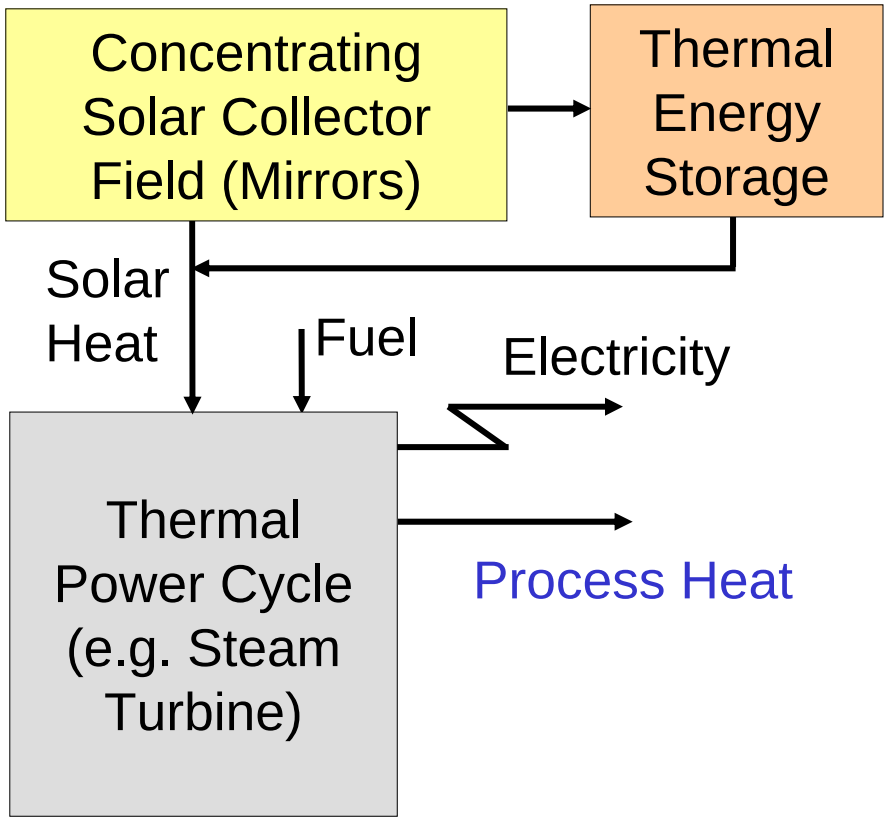
- ✓ Coal, Lignite
- ✓ Oil, Gas
- ✓ Nuclear Fission, Fusion
- ✓ Concentrating Solar Power (CSP)
- ✓ Geothermal Power (Hot Dry Rock)
- ✓ Biomass
- ✓ Hydropower
- ✓ Wind Power
- ✓ Photovoltaic
- ✓ Wave / Tidal

ideally stored primary energy

storable primary energy

fluctuating primary energy

Principle of a Concentrating Solar Thermal Power Plant



- concentrated, easily storable solar thermal energy as fuel saver
- spinning reserve
- firm capacity, power on demand
- combined generation of process heat for cooling, industry, desalination, etc.

ANDASOL, Guadix, Spain
Capacity 2 x 50 MW_{el}
Storage 2 x 1000 MWh_{th}

High Voltage Direct Current Transmission in China

Voltage:	± 800.000 Volt
Power:	6400 Megawatt
Length:	2070 km
Source:	Hydropower
Losses:	7%

Renewable Energy Technologies

Geothermal

Hydropower

Concentrating
Solar Power

Biomass

Tides

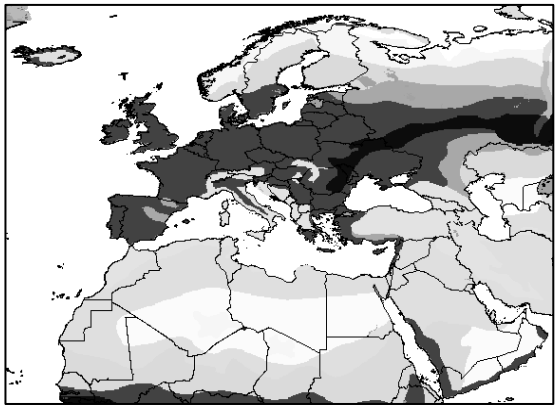
Waves

Photovoltaic

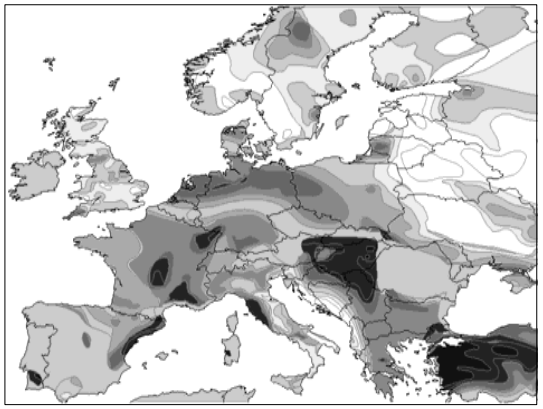
Wind Power

Renewable Electricity Potential in Europe, Middle East & North Africa

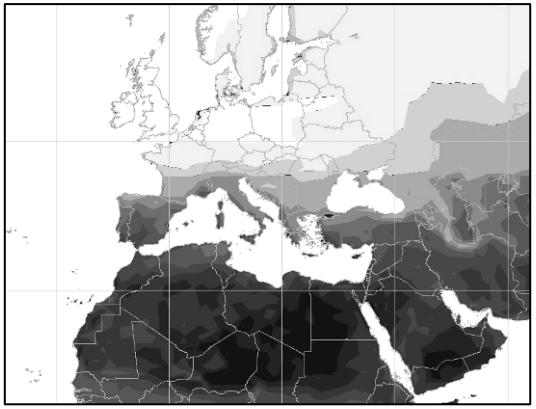
Biomass (0-1)

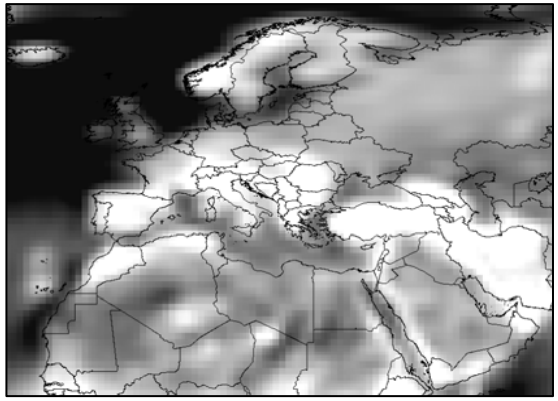


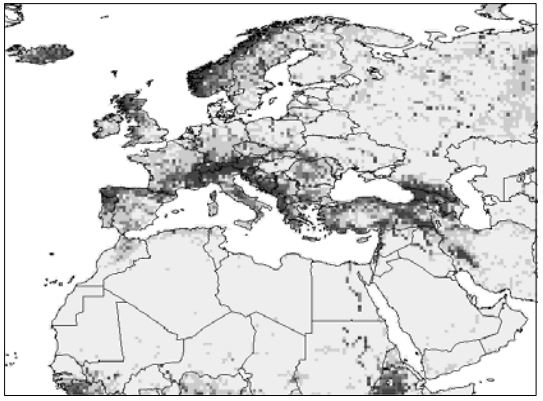
Geothermal (0-1)



Solar (10-250)







Max

Min

Electricity Yield
in GWh/km²/y

Wind Energy (5-50)

Hydropower (0-50)

Criteria for Sustainable Electricity Supply:

✓ **Inexpensive**

low cost
no long term subsidies

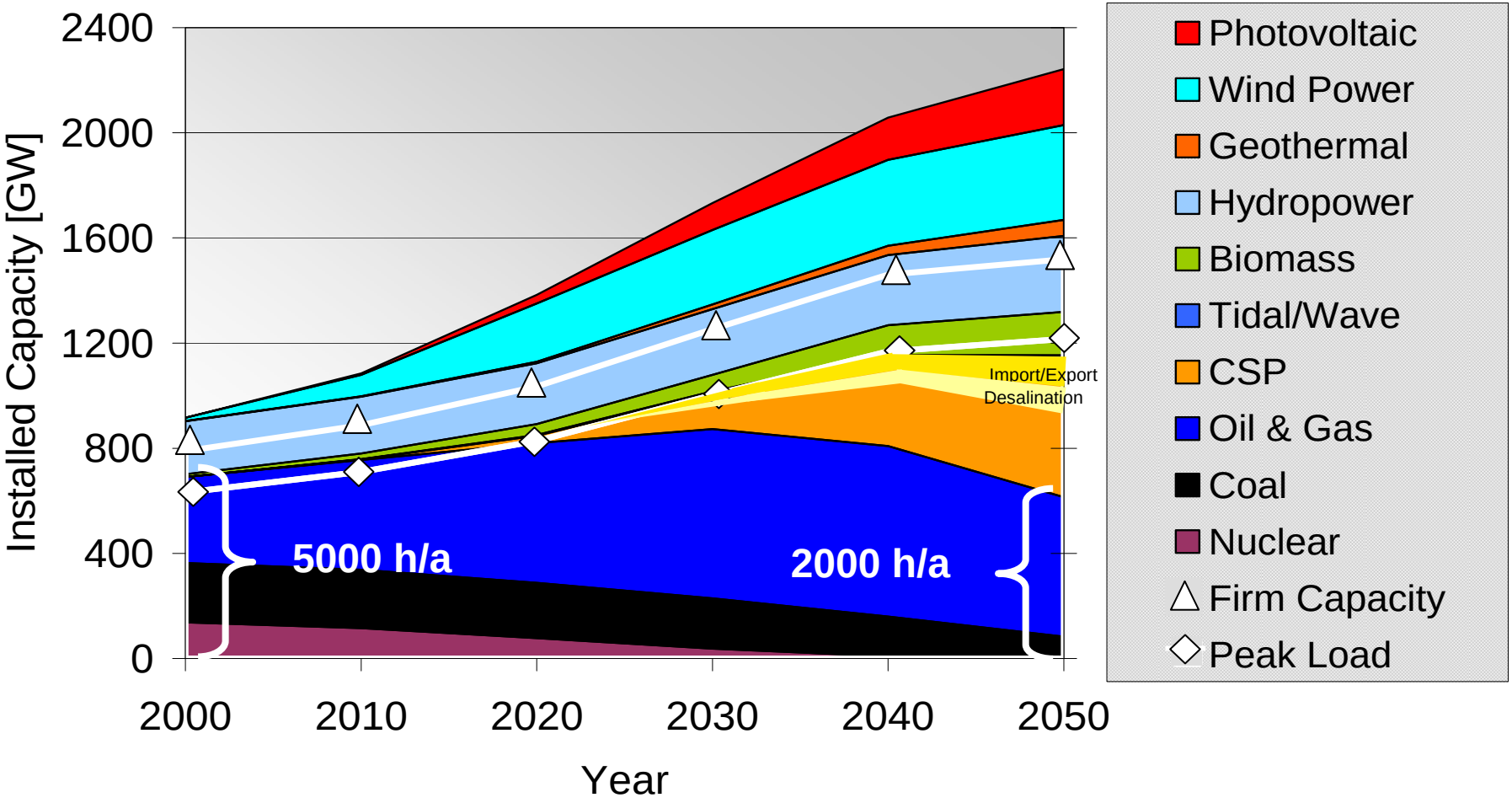
✓ **Secure**

diversified and redundant supply
power on demand
inexhaustible resources
available technology

✓ **Compatible**

low pollution
climate protection
low risks for health and environment
fair access

Installed Capacity vs. Peak Load in EUMENA

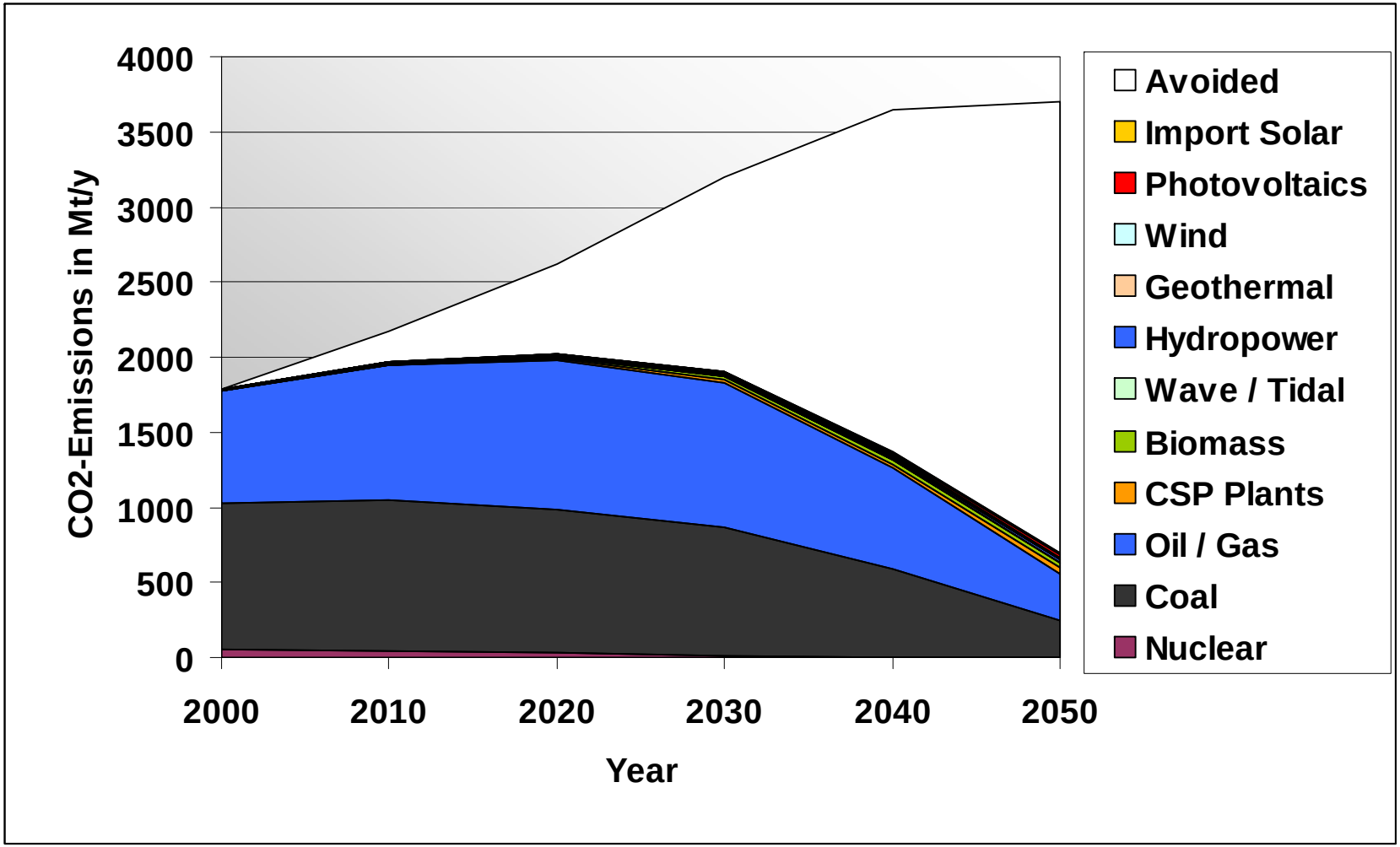


➔ **100 % availability plus 25 % reserve capacity**

Availability and Redundancy

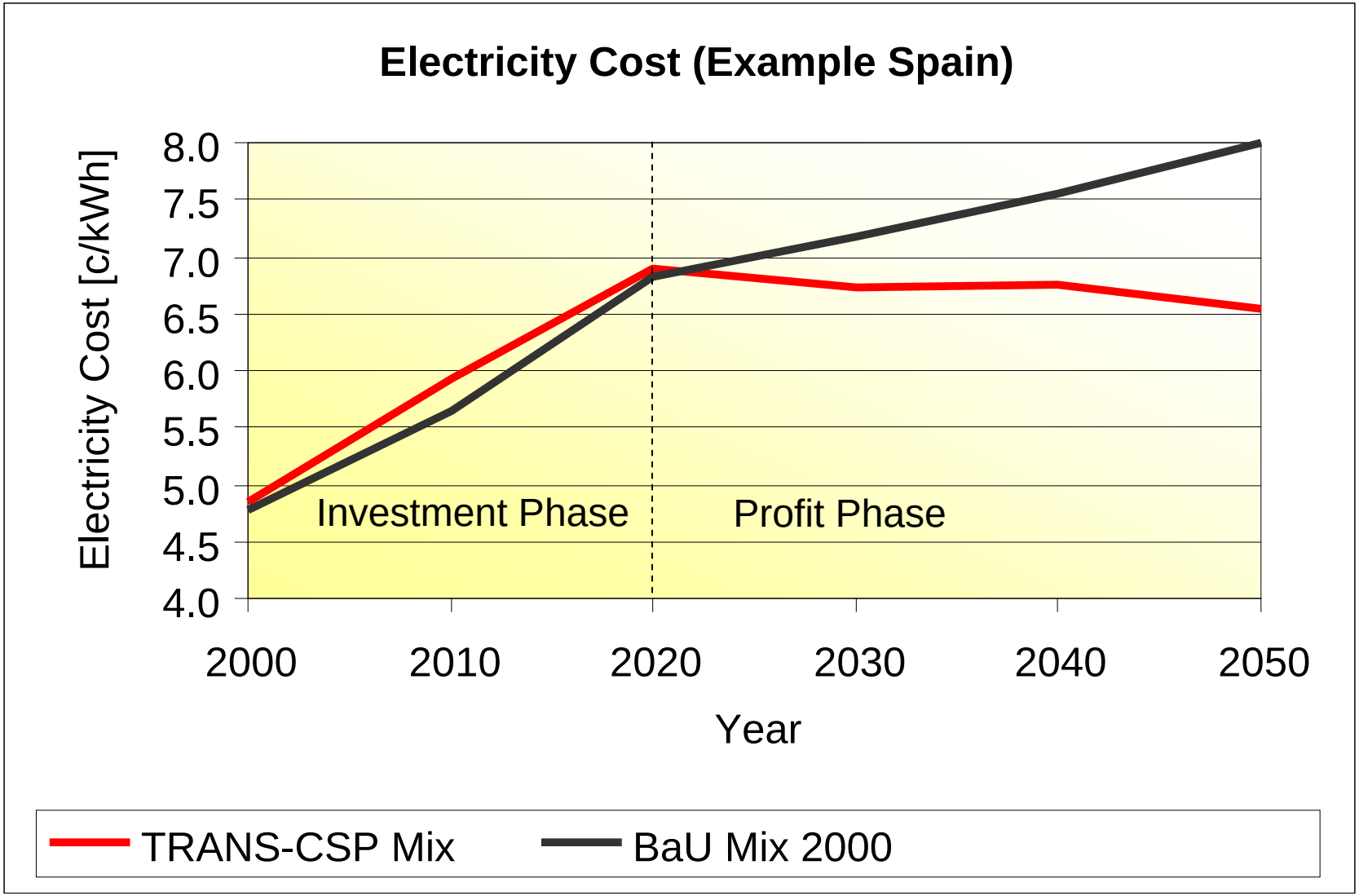
- **Power on Demand by a Mix of Fluctuating and Balancing Sources**
- **Increased Number of Non-Correlated Energy Sources**
- **Increased Number and Reduced Average Size of Power Plants**
- **Increased Number of Supply Regions**
- **Additional HVDC Grid Infrastructure for Long-Distance Transfer**
- **Domestic Sources Dominate the Electricity Mix**
- **Renewable Sources Dominate the Electricity Mix**
- **Strategy Based on Proven Technologies**

Carbon emissions of EUMENA power sector are reduced to 38 % until 2050 in spite of a quickly growing demand



Environmental Security

- **Reduced Life Cycle Greenhouse Gas Emissions of Power Generation**
- **Reduced Risks of Nuclear Radiation and Proliferation**
- **Reduced Local Pollution by Combustion Products**
- **Optimal Land Use (1%) through Diversified Mix**
- **Technology based on Recyclable Materials**


Electricity Cost (Example Spain)
Electricity Cost [c/kWh]
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
Investment Phase
Profit Phase
2000
2010
2020
2030
2040
2050
Year
TRANS-CSP Mix
BaU Mix 2000

Economic Security

- **Economic Risk Hedged by Increased Portfolio**
- **Intrinsic Trend to Lower Cost and Lower Price Volatility**
- **Energy Cost Stabilization through Investment in New Sources**
- **Prevention of Cost Escalation due to Environmental Constraints**
- **Prevention of Cost Escalation due to Scarcity**
- **Reduction of Energy Subsidies in Europe and MENA**

Solar Power & Desalination Plants

Energy,
Water,
Food,
Labor and
Income

for further
300 Million
People
in MENA ?

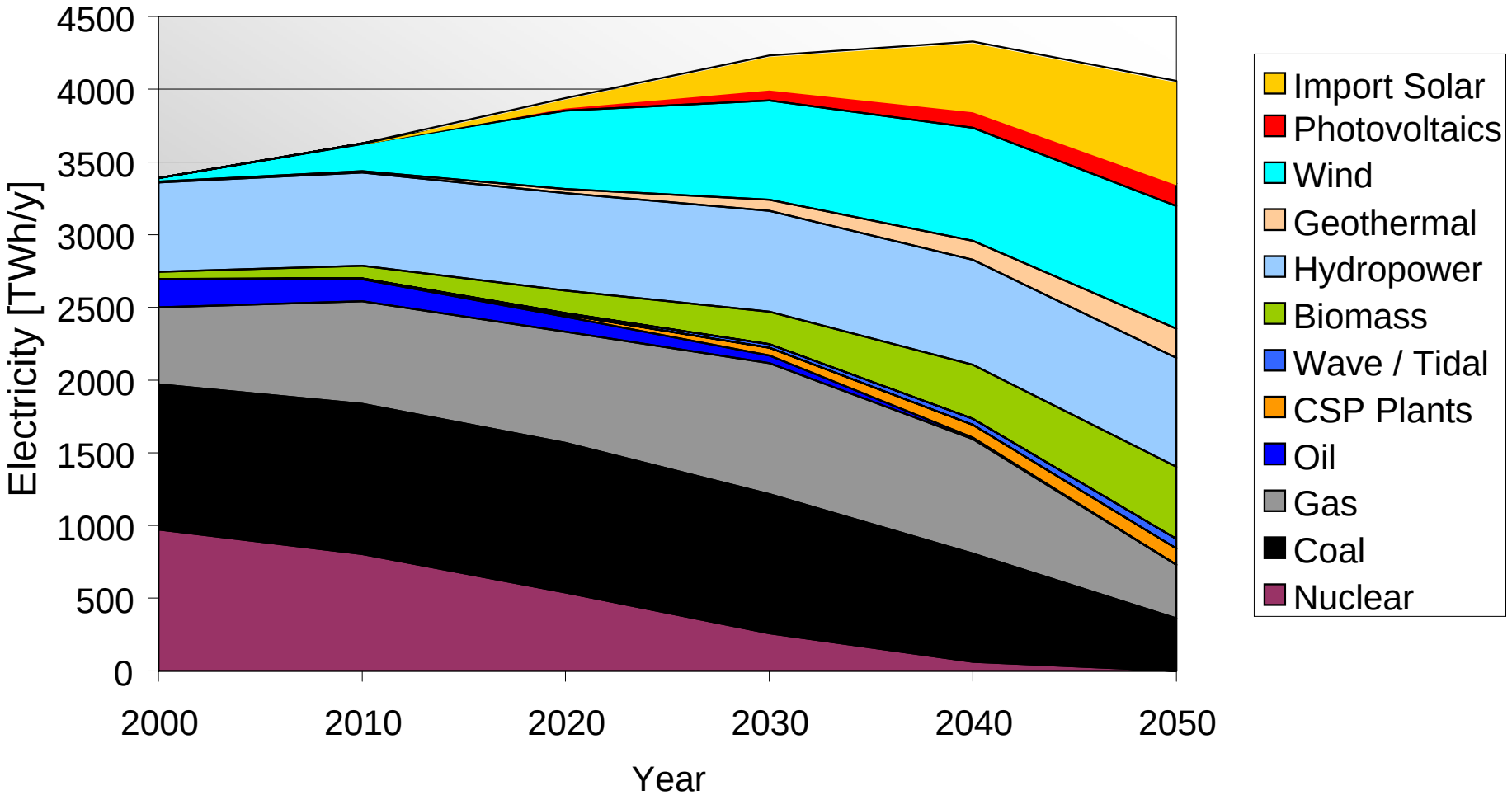
(artist view created with Google Earth)

Political Security

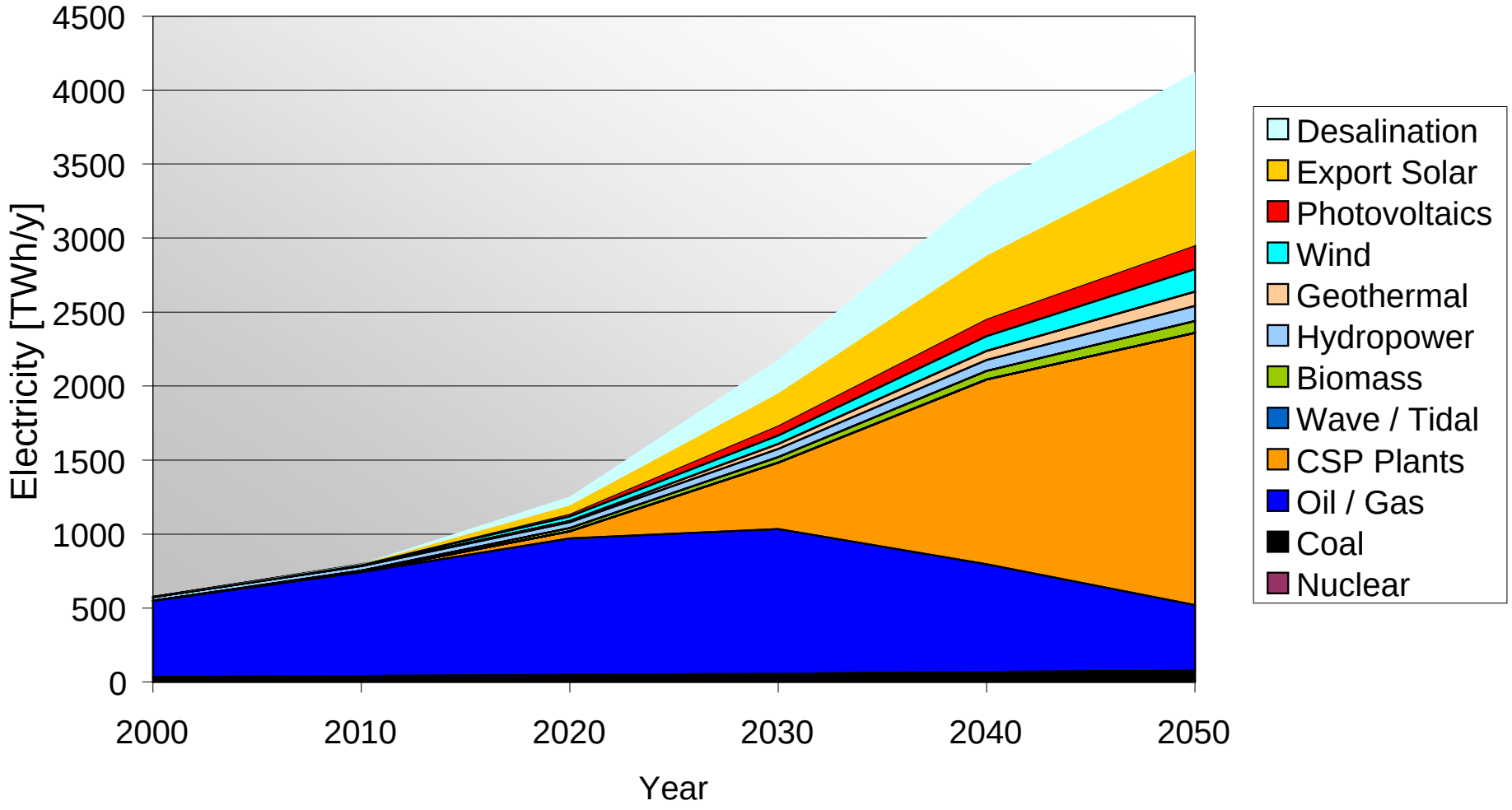
- **Conflict Prevention between EU and MENA Reducing Pressure on Fuels**
- **Conflict Prevention in MENA Solving Energy and Water Scarcity**
- **Conflict Prevention in Europe Increasing Energy Diversity**
- **Reduction of European Energy Import Dependency**
- **Addition of Energy Corridors for European Supply**
- **Initiating EU-MENA (Energy) Partnership**

Thank You!

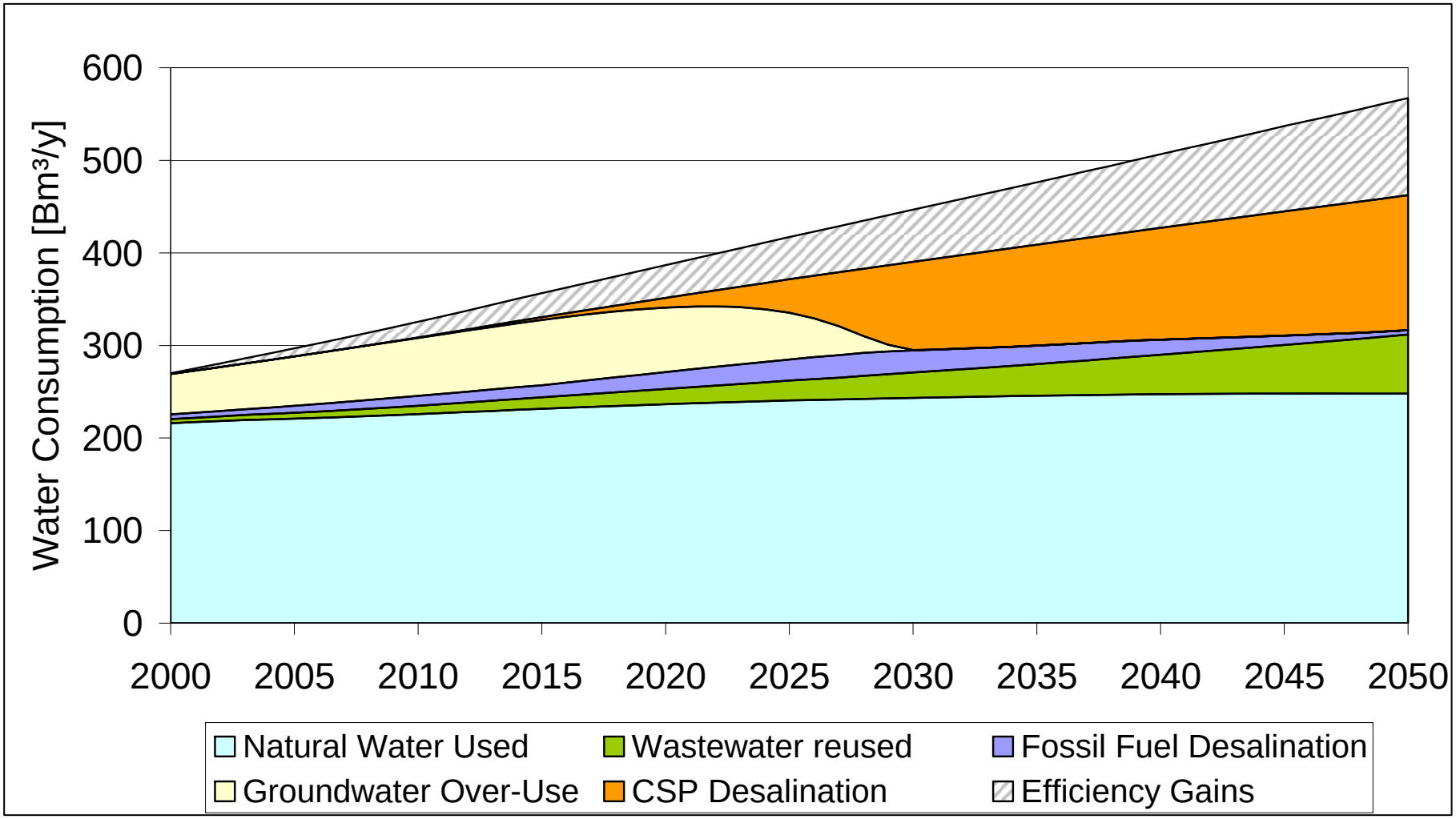
Electricity Supply in Europe (TRANS-CSP Scenario)



Electricity Supply in the Middle East & North Africa



AQUA-CSP Scenario for Middle East & North Africa

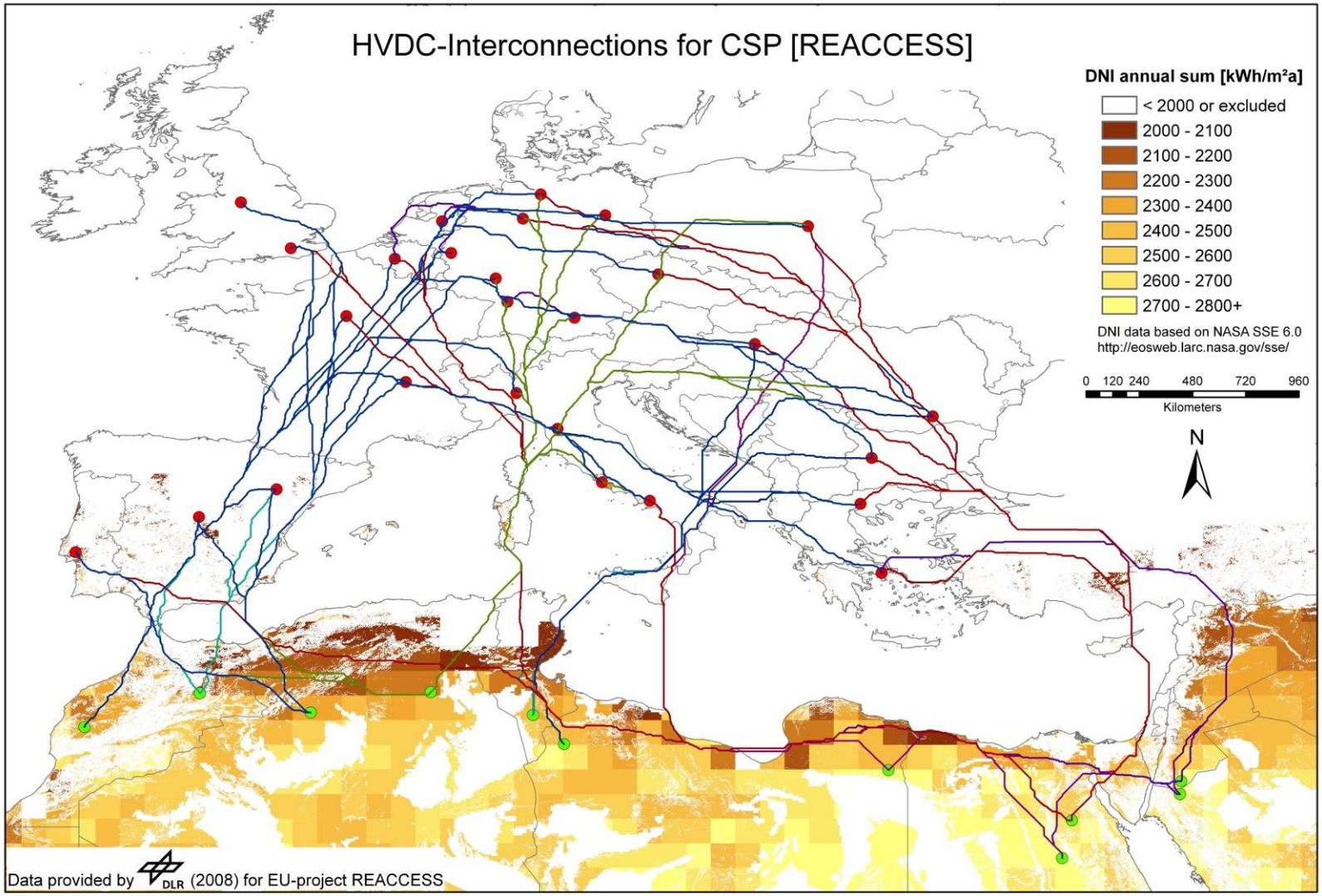


Total EU-MENA HVDC Interconnection 2020 – 2050 *

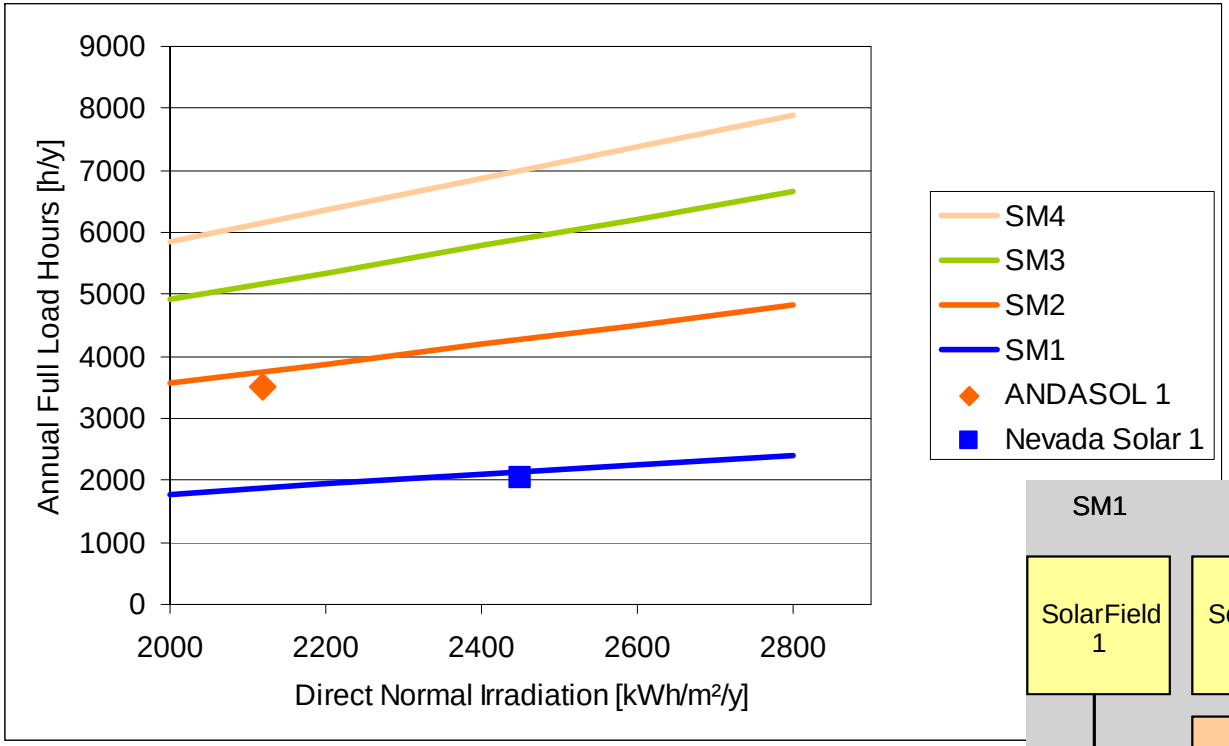
Year		2020	2030	2040	2050
Lines x Capacity GW		4 x 2.5	16 x 2.5	28 x 2.5	40 x 2.5
Transfer TWh/y		60	230	470	700
Capacity Factor		0.60	0.67	0.75	0.80
Turnover Billion €/y		3.8	12.5	24	35
Land Area	CSP	15 x 15	30 x 30	40 x 40	50 x 50
km x km	HVDC	3100 x 0.1	3600 x 0.4	3600 x 0.7	3600 x 1.0
Cum. Investment	CSP	42	134	245	350
Billion €	HVDC	5	16	31	45
Elec. Cost	CSP	0.050	0.045	0.040	0.040
€/kWh	HVDC	0.014	0.010	0.010	0.010

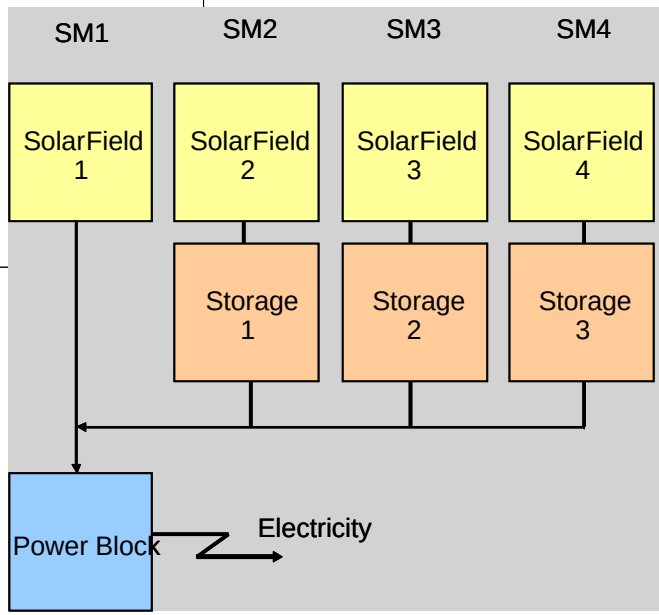
* All countries analysed in TRANS-CSP

Solar Electricity Corridors to Europe: REACCESS



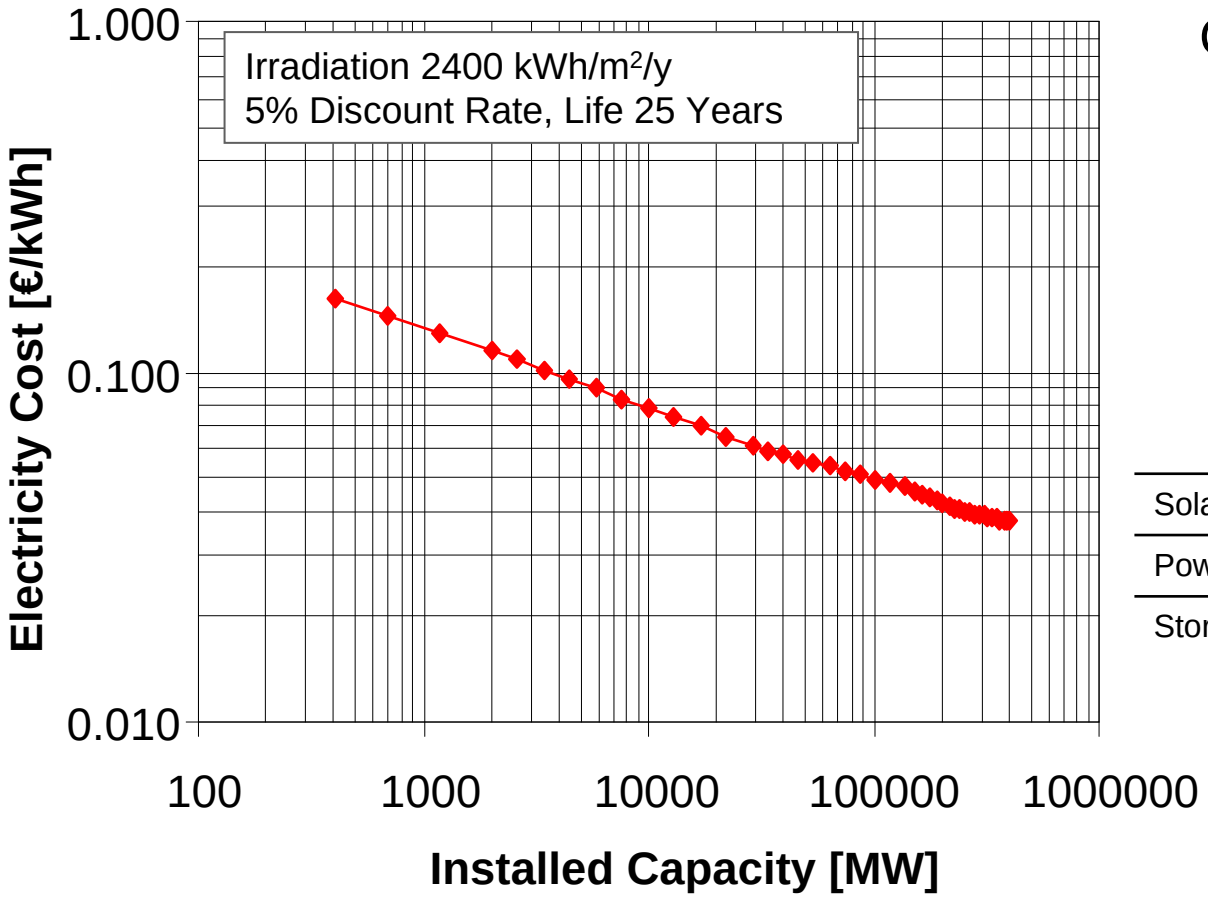
Effect of Thermal Energy Storage on the Availability of CSP





SM = Solar Multiple
1 Solar Field = 6000 m²/MW
1 Storage = 6 hours (full load)

Cost of Concentrating Solar Power

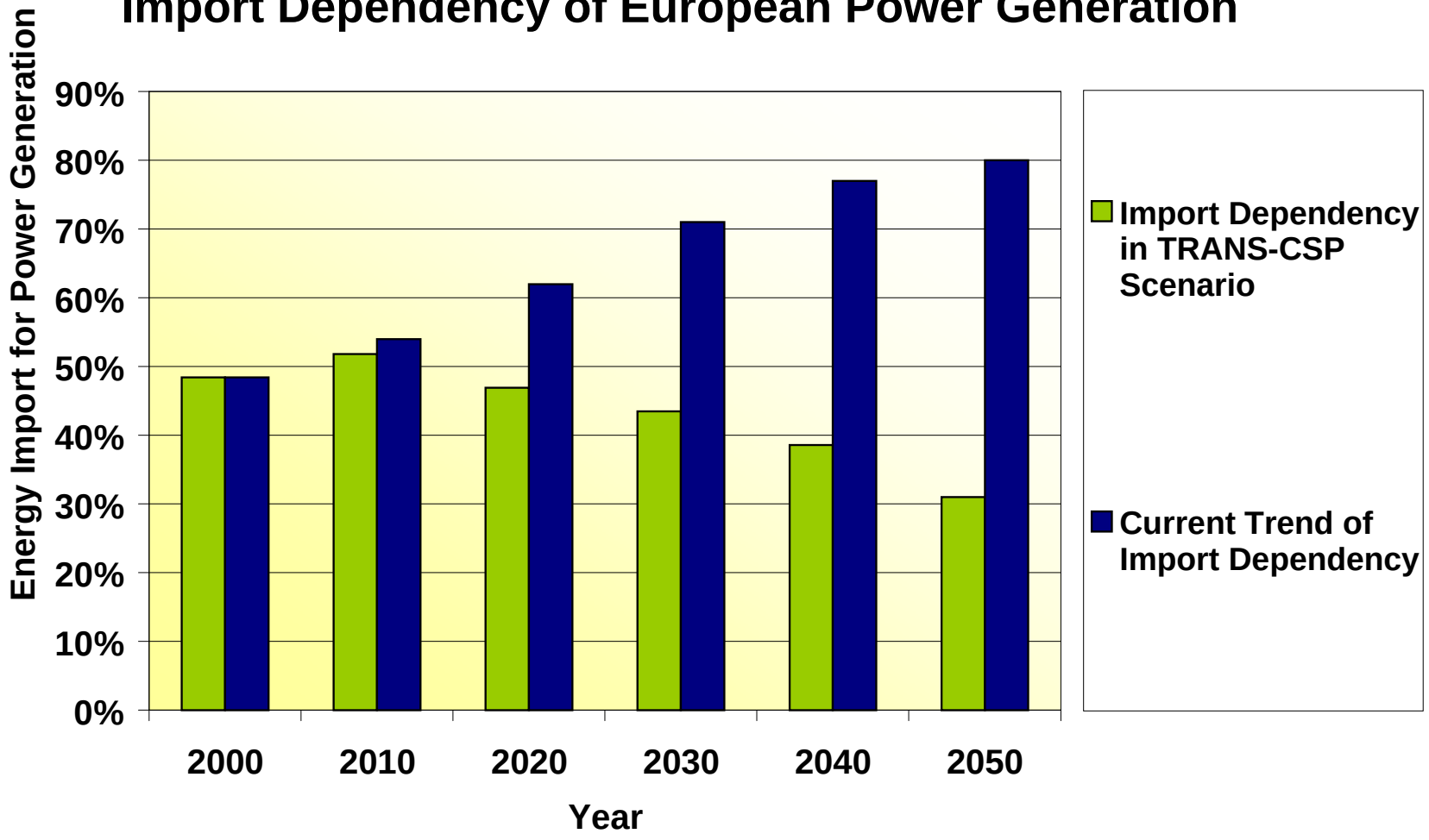


CSP Learning Curve

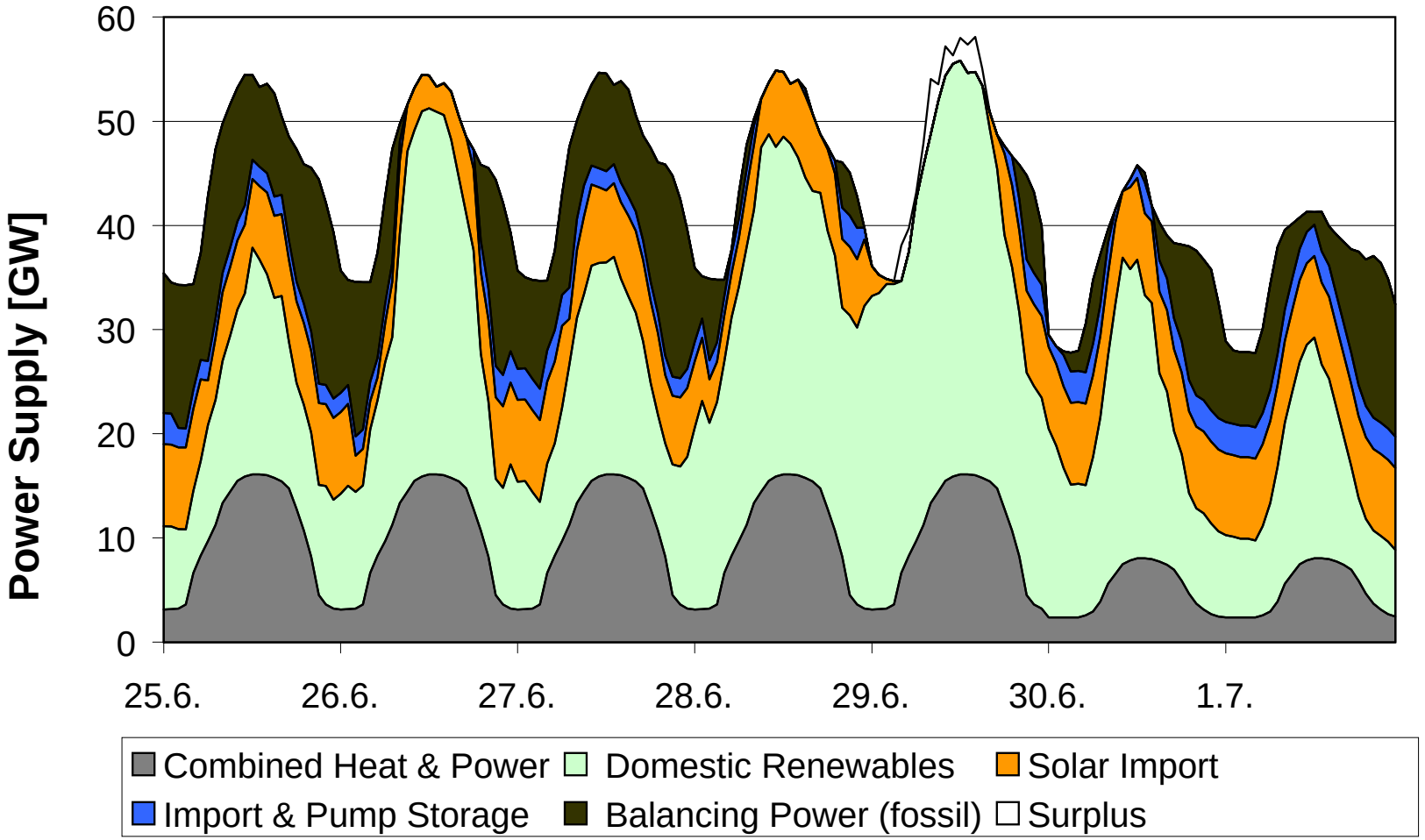
$$c_x = c_0 \left(\frac{P_x}{P_0} \right)^{\frac{\log PR}{\log 2}}$$

	Progress Ratio (PR)	Start 2005 (c0)
Solar Field	90%	360 €/m2
Power Block	98%	1200 €/kW
Storage	92%	60 €/kWh

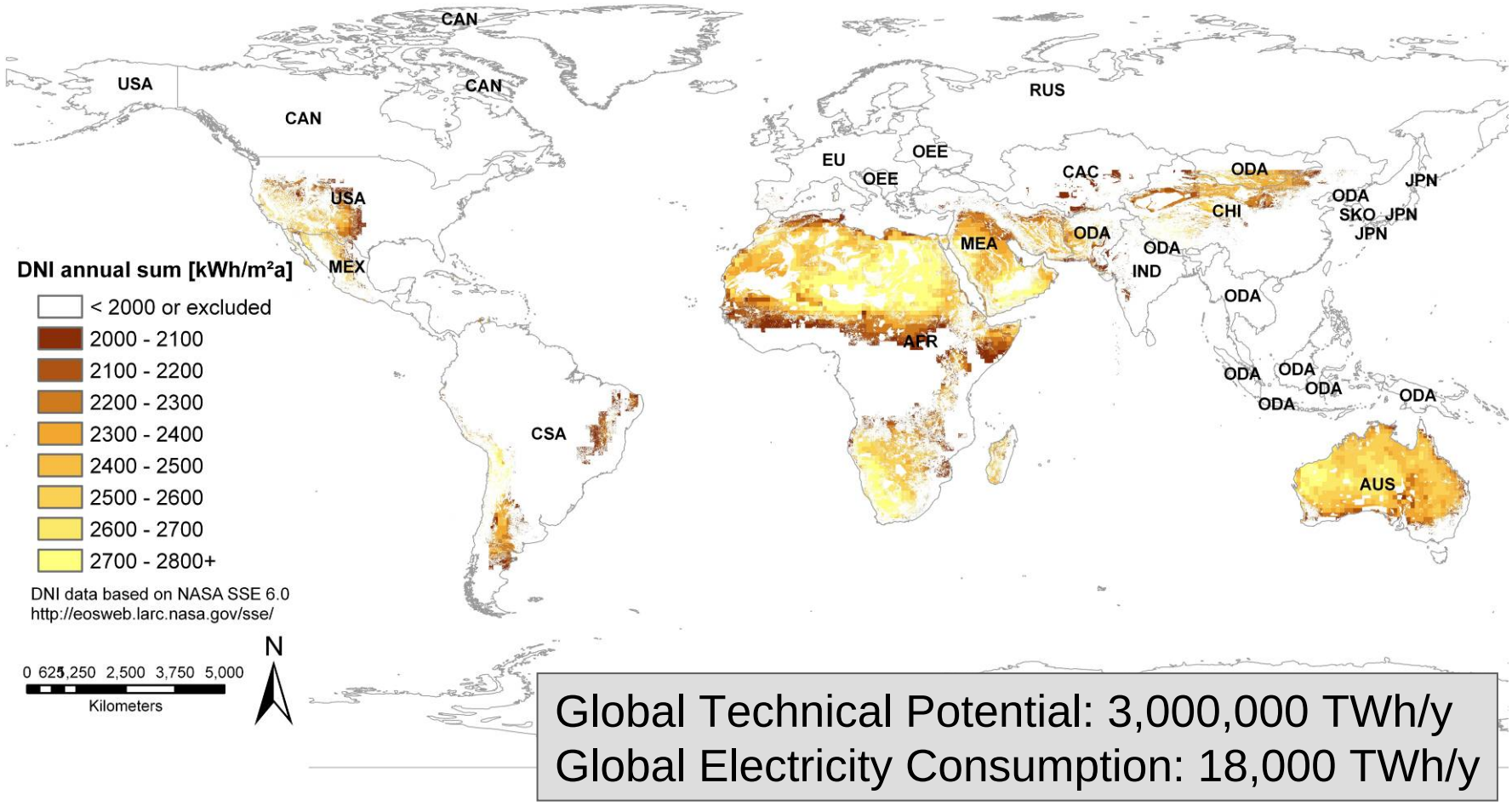
Import Dependency of European Power Generation



Firm Power Capacity based on Renewables and Fuel (no fossil or nuclear base load supply)



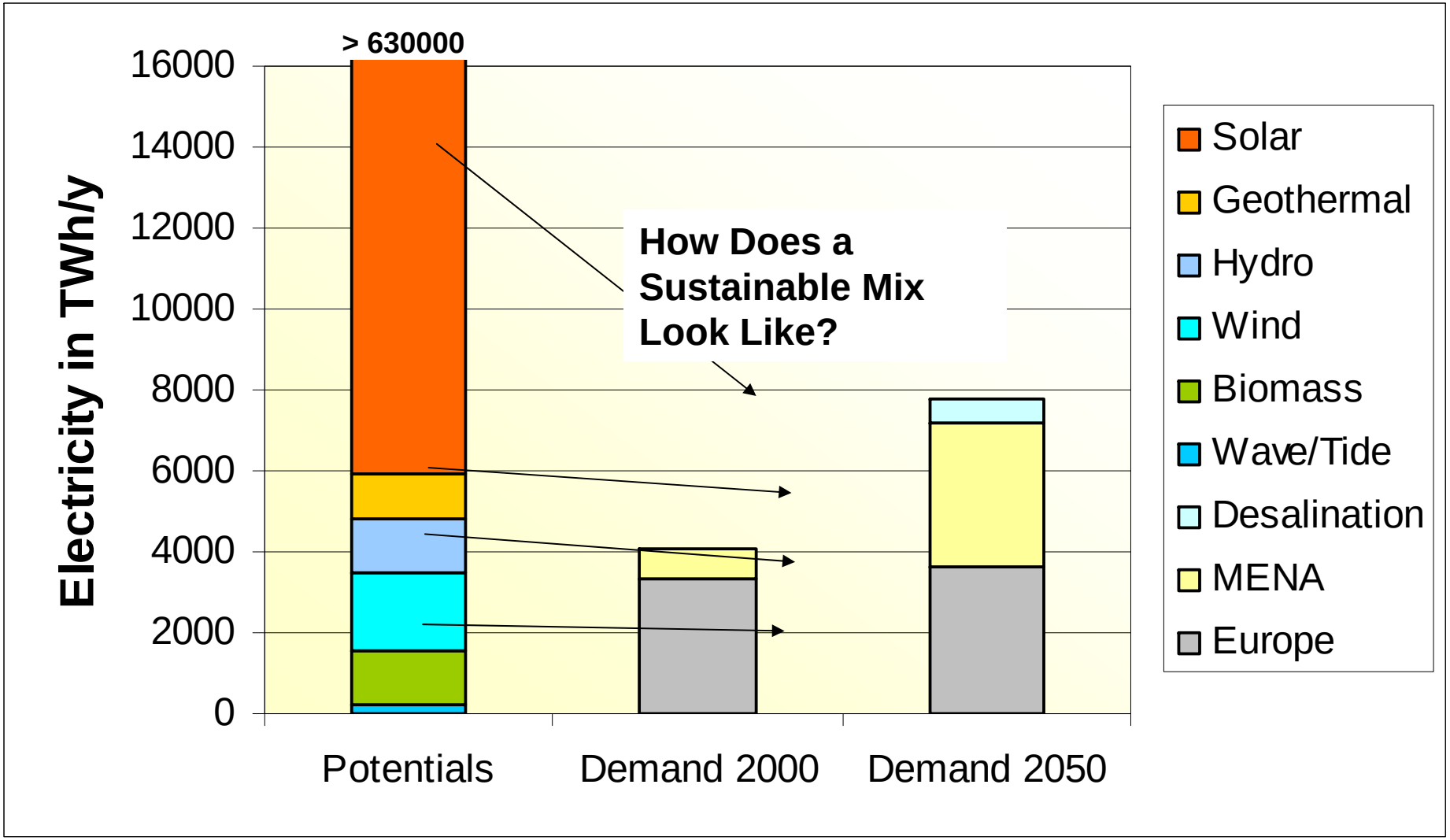
Global Potential for Concentrating Solar Power



Global Technical Potential: 3,000,000 TWh/y
Global Electricity Consumption: 18,000 TWh/y

Data provided by DLR (2008) for EU-project REACCESS

Economic Renewable Electricity Potentials vs. Demand in EUMENA



Challenges

- Requires New Structures and New Thinking (Change of Paradigm)
- Requires Long-Term Financing Scheme for Large Infrastructure
- Based on International Cooperation and Interdependencies
- Higher Complexity than Using Ideally Stored Fossil Energy Sources
- More Stakeholders Involved due to Decentralized Generation
- Cultural and Political Differences in EUMENA
- Lobby Groups Acting Against Each Other
- Speed of Environmental Change and Conflict Potentials

Studies:

Assessment of the renewable energy potential for the sustainable supply of electricity and water in 50 countries of Europe, the Middle East and North Africa taking into consideration the option of Concentrating Solar Power (CSP).

Bundesministerium
für Umwelt, Naturschutz
und Reaktorsicherheit

German Feed-In Law: Impact on Consumers